PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Takeshi SUZUKI

Application No.: 10/029,210

Filed: December 28, 2001 Docket No.: 111606

For: PROJECTION OPTICAL SYSTEM AND EXPOSURE APPARATUS WITH THE SAME

PRELIMINARY AMENDMENT

Director of the U.S. Patent and Trademark Office
Washington, D. C. 20231

Sir:

Prior to initial examination on the merits, please amend the above-identified application as follows:

IN THE ABSTRACT:

Please replace the current Abstract with the revised Abstract attached hereto.

IN THE SPECIFICATION:

Page 7, line 19 - page 8, line 18, delete current paragraph and insert therefor:

In the projection optical system according to the above-mentioned condition, it is preferable that at least one lens component among lens components formed of the fluorite within the first lens group has a positive refractive power. As described above, with respect to the structure of the first lens group, effects of aberration deterioration due to irradiation fluctuations in the first lens group, such as coma, the difference between the periphery and the center in the projection area, or the like are larger than such effects in other lens groups. In particular, in a positive lens, with respect to an optical path length going through a glass

material, a light beam going though at the optical axis center is longer than a light beam going through the periphery; therefore, effects of irradiation fluctuation on a glass material are easily generated. Thus, from the standpoint of efficiently controlling aberration fluctuation due to irradiation fluctuation, it is preferable that a fluorite glass material is used for lenses having a positive refractive power. Additionally, from a perspective of chromatic aberration correcting occurring due to the difference in the refractive index of fluorite, it is preferable that a fluorite glass material is used for lenses having a positive refractive power.

Page 8, line 19 - page 9, line 7, delete current paragraph and insert therefor:

Furthermore, in the projection optical system according to the above-mentioned aspect, it is preferable that the third lens group has at least one lens component formed of fluorite. A light beam which is diverged by the second lens group is converged by the third lens group, so each lens of the third lens group has a high irradiating energy density. This causes compaction, which is a type of irradiation fluctuation. If a fluorite glass material is used for the third lens group, an effect can be obtained which reduces the effect of this compaction. Furthermore, if a fluorite glass material is used for a glass material with thickness close to the point at which the irradiating energy density is focused, compaction can be further effectively corrected.

Page 20, line 15 - page 21, line 2, delete current paragraph and insert therefor:

Fig. 5 is a structural diagram of a projection exposure apparatus to which the projection optical system of the first or second embodiments is applied as a projection optical system PL. A mask (a reticle R) in which a predetermined pattern is formed is arranged on the reticle R surface of the projection optical system PL. A wafer W coated by a photoresist is arranged, as a workpiece, at the wafer W surface of the projection optical system PL. The reticle R is held on a reticle stage RS, and the wafer W is held on a wafer stage WS. Above the reticle R, an illumination optical system IS is arranged which includes the exposure light

source and uniformly illuminates the reticle R. Here, ArF laser is used as the exposure light source.

IN THE CLAIMS:

Please replace claims 1 and 17-20 as follows:

1. (Amended) A projection optical system which projects an image of a first surface onto a second surface, and which has a lens component formed of fluorite and a lens component formed of silica, comprising:

a first lens group including at least one lens component formed of fluorite and having a positive refractive power;

a second lens group which is arranged in an optical path between the first lens group and the second surface and which has a negative refractive power; and

a third lens group which is arranged in an optical path between the second lens group and the second surface and having a positive refractive power;

wherein when the number of the lens components formed of silica is Snum, the number of the lens components formed of fluorite is Cnum, and a numerical aperture of the second surface side of the projection optical system is NA, the following conditions are satisfied:

$$\mathrm{Snum} > \mathrm{Cnum}$$

$$\mathrm{NA} > 0.75.$$

17. (Amended) A projection exposure apparatus which projects and exposes a reduced image of a pattern arranged in a mask onto a workpiece, comprising:

a light source having a center wavelength of 200 nm or less;

an illumination optical system which guides exposure light from the light source to the pattern on the mask; and

the projection optical system as set forth in claim 1;

wherein the mask can be arranged at the first surface, and the workpiece can be arranged at the second surface.

18. (Amended) A projection exposure apparatus which projects and exposes a reduced image of a pattern arranged in a mask onto a workpiece, comprising:

a light source having a center wavelength of 200 nm or less;

an illumination optical system which guides exposure light from the light source to the pattern on the mask; and

the projection optical system as set forth in claim 2;

wherein the mask can be arranged at the first surface, and the workpiece can be arranged at the second surface.

19. (Amended) A projection exposure method which projects and exposes a reduced image of a pattern arranged in a mask onto a workpiece, comprising the steps of:

supplying exposure light having a center wavelength of 200 nm or less;

guiding the exposure light to the pattern on the mask; and

projecting an image of the pattern on the mask arranged at the first surface onto the workpiece arranged at the second surface by using the projection optical system as set forth in claim 1.

20. (Amended) A projection exposure method which projects and exposes a reduced image of a pattern arranged in a mask onto a workpiece, comprising the steps of:

supplying exposure light having a center wavelength of 200 nm or less;

guiding the exposure light to the pattern on the mask; and

projecting an image of the pattern on the mask arranged at the first surface onto the workpiece arranged at the second surface by using the projection optical system as set forth in claim 2.

REMARKS

Claims 1-20 are pending. By this Amendment, claims 1 and 17-20 are amended for clarity. These amendments do not narrow the claims. In addition, the Abstract is amended to better comply with U.S. practice, and the specification is amended for clarity. No new matter is added by these amendments. The attached Appendix includes marked-up copies of each rewritten paragraph (37 C.F.R. §1.121(b)(1)(iii)) and claim (37 C.F.R. §1.121(c)(1)(ii)).

Examination and allowance in due course are earnestly solicited.

Respectfully submitted,

Mario A. Costantino
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MAC/ccs

Attachments:
Abstract
Appendix

Date: April 22, 2002

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DEPOSIT ACCOUNT USE AUTHORIZATION
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ABSTRACT

A projection optical system projects an image of a first surface onto a second surface, and has a lens component formed of fluorite and a lens component formed of silica, and further includes: a first lens group including at least one lens component formed of fluorite and having a positive refractive power; a second lens group which is arranged in an optical path between the first lens group and the second surface and which has a negative refractive power; and a third lens group which is arranged in an optical path between the second lens group and the second surface and having a positive refractive power; wherein when the number of the lens components formed of silica is Snum, the number of the lens components formed of fluorite is Cnum, and a numerical aperture of the second surface side of the projection optical system is NA, the following conditions are satisfied:

Snum>Cnum (1)

NA>0.75 (2).

APPENDIX

Changes to Abstract:

The following is a marked-up version of the amended Abstract:

ABSTRACT

~~The~~A projection optical system~~, includes:~~ projects an image of a first surface onto a second surface, and has a lens component formed of fluorite and a lens component formed of silica, and further includes: a first lens group including at least one lens component formed of fluorite and having a positive refractive power; a second lens group which is arranged in an optical path between the first lens group and the second surface and which has a negative refractive power; and a third lens group which is arranged in an optical path between the second lens group and the second surface and having a positive refractive power; wherein when the number of the lens components formed of silica is Snum, the number of the lens components formed of fluorite is Cnum, and a numerical aperture of the second surface side of the projection optical system is NA, the following conditions are satisfied:

~~a lens component formed of fluorite;~~

~~a lens component formed of quartz;~~

~~a first lens group including at least one lens component formed of fluorite and having a positive refractive power;~~

~~a second lens group arranged in an optical path between the first lens group and the second surface and having a negative refractive power; and~~

~~a third lens group arranged in an optical path between the second lens group and the second surface and having a positive refractive power;~~

~~wherein when the number of the lens components formed of quartz is Snum, the number of the lens components formed of fluorite is Cnum, and a numerical aperture of the~~

~~second surface side of the projection optical system is NA, the following conditions are satisfied:~~

Snum>Cnum (1)

NA>0.75 (2).

Changes to Specification:

Page 7, line 19 - page 8, line 18:

In the projection optical system according to the above-mentioned condition, it is preferable that at least one lens component among lens components formed of the fluorite within the first lens group has a positive refractive power. As described above, with respect to the structure of the first lens group, effects of aberration deterioration due to irradiation fluctuations in the first lens group, such as coma, the difference between the periphery and the center in the projection area, or the like are larger than such effects in other lens groups. In particular, in a ~~convex~~positive lens, with respect to an optical path length going through a glass material, a light beam going though at the optical axis center is longer than a light beam going through the periphery; therefore, effects of irradiation fluctuation on a glass material are easily generated. Thus, from the standpoint of efficiently controlling aberration fluctuation due to irradiation fluctuation, it is preferable that a fluorite glass material is used for lenses having a positive refractive power. Additionally, from a perspective of chromatic aberration correcting occurring due to the difference in the refractive index of fluorite, it is preferable that a fluorite glass material is used for lenses having a positive refractive power.

Page 8, line 19 - page 9, line 7:

Furthermore, in the projection optical system according to the above-mentioned aspect, it is preferable that the third lens group has at least one lens component formed of fluorite. A light beam which is diverged by the second lens group is converged by the third

lens group, so each lens of the third lens group has a high irradiating energy density. This causes compaction, which is a type of irradiation fluctuation. If a fluorite glass material is used for the third lens group, an effect can be obtained which reduces the effect of this compaction. Furthermore, if a fluorite glass material is used for a glass material with thickness close to the ~~plane~~point at which the irradiating energy density is focused, compaction can be further effectively corrected.

Page 20, line 15 - page 21, line 2:

Fig. 5 is a structural diagram of a projection exposure apparatus to which the projection optical system of the first or second embodiments is applied as a projection optical system PL. A ~~projection negative plate~~mask (a reticle R) in which a predetermined pattern is formed is arranged on the reticle R surface of the projection optical system PL. A wafer W coated by a photoresist is arranged, as a workpiece, at the wafer W surface of the projection optical system PL. The reticle R is held on a reticle stage RS, and the wafer W is held on a wafer stage WS. Above the reticle R, an illumination optical system IS is arranged which includes the exposure light source and uniformly illuminates the reticle R. Here, ArF laser is used as the exposure light source.

Changes to Claims:

The following are marked-up versions of the amended claims:

1. (Amended) A projection optical system which projects an image of a first surface onto a second surface, and which has a lens component formed of fluorite and a lens component formed of silica, comprising:

~~a lens component formed of fluorite;~~

~~a lens component formed of quartz;~~

a first lens group including at least one lens component formed of fluorite and having a positive refractive power;

a second lens group which is arranged in an optical path between the first lens group and the second surface and ~~having~~which has a negative refractive power; and

a third lens group which is arranged in an optical path between the second lens group and the second surface and having a positive refractive power;

wherein when the number of the lens components formed of ~~quartz~~silica is Snum, the number of the lens components formed of fluorite is Cnum, and a numerical aperture of the second surface side of the projection optical system is NA, the following conditions are satisfied:

Snum>Cnum

NA>0.75.

17. (Amended) A projection exposure apparatus which projects and exposes a reduced image of a pattern arranged in a ~~projection negative plate~~mask onto a workpiece, comprising:

a light source having a center wavelength of 200 nm or less;

an illumination optical system which guides exposure light from the light source to the pattern on the ~~projection negative plate~~mask; and

the projection optical system as set forth in claim 1;

wherein the ~~projection negative plate~~mask can be arranged at the first surface, and the workpiece can be arranged at the second surface.

18. (Amended) A projection exposure apparatus which projects and exposes a reduced image of a pattern arranged in a ~~projection negative plate~~mask onto a workpiece, comprising:

a light source having a center wavelength of 200 nm or less;

an illumination optical system which guides exposure light from the light source to the pattern on the ~~projection negative plate~~mask; and

the projection optical system as set forth in claim 2;

wherein the ~~projection negative plate~~mask can be arranged at the first surface, and the workpiece can be arranged at the second surface.

19. (Amended) A projection exposure method which projects and exposes a reduced image of a pattern arranged in a ~~projection negative plate~~mask onto a workpiece, comprising the steps of:

supplying exposure light having a center wavelength of 200 nm or less;

guiding the exposure light to the pattern on the ~~projection negative plate~~mask; and

projecting an image of the pattern on the ~~projection negative plate~~mask arranged at the first surface onto the workpiece arranged at the second surface by using the projection optical system as set forth in claim 1.

20. (Amended) A projection exposure method which projects and exposes a reduced image of a pattern arranged in a ~~projection negative plate~~mask onto a workpiece, comprising the steps of:

supplying exposure light having a center wavelength of 200 nm or less;

guiding the exposure light to the pattern on the ~~projection negative plate~~mask; and

projecting an image of the pattern on the ~~projection negative plate~~mask arranged at the first surface onto the workpiece arranged at the second surface by using the projection optical system as set forth in claim 2.